Exploring Email-Prompted Information Needs

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Over three billion people use personal email accounts for a wide variety of communications, largely from businesses. These messages often require additional information that users need to look for outside of the email itself, such as store hours, bill details, or related news articles. We studied these "email-prompted information needs" in a pilot interview-based study, a two-week diary study, and a large-scale survey with 790 total participants, finding that *Notification*, *Deal*, and *Newsletter* messages were the most likely to spark a need for external information. We conclude with several designs evaluated in a concept evaluation study with 276 participants and implications for the design of personal email services to better meet users' external information needs.

CCS Concepts: • **Human-centered computing** → **Empirical studies in HCI**; *User studies*; • **Information systems** → **Email**; *Personalization*; *Search interfaces*.

Additional Key Words and Phrases: Email; Information Needs; Diary Study; Survey

1 INTRODUCTION

Email remains a growing area of internet use, with new accounts growing at 7% annually and over three billion people holding email accounts. [35] As a category, this is more than users of Facebook [20] or other social platforms widely studied in HCI. The use of these personal email accounts has changed radically over the past decade. With the rise of messaging apps for personal communication, personal email accounts have become the primary place for users to interact with businesses: receiving deals, receipts from online purchases, and newsletters from the companies and brands in their lives [4].

While some research has explored the types of messages that users receive and open in their personal accounts [4, 22], little has been studied about what users do just after reading an email message and the types of information needs that emails may prompt. Daskalova et al. [17] explored the use of email coupons, and the types of deals that were most often redeemed. However, users receive many other types of emails in their personal accounts and the information needs around these have not been deeply studied. An email that a user receives may not have all of the information that they need for a particular situation. Emails might prompt a user to go looking for additional

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information that is not contained in the message body. For example, a user might need the opening hours or map of a store location after viewing a promotional message, an email from a politician might prompt them to look up current poll data or news about that candidate, or an email about a credit card bill might prompt them to look up information such as the amount that is due or the minimum payment.

We term these types of situations "*email-prompted information needs*," by which we mean *any information that a user attempts to look up after reading an email that is related to, or sparked by, viewing the email content.* We are interested in the types of email-prompted information needs that people have, their frequency, and how we might better design email clients to support these information needs to simplify the information foraging process [31].

Exploring this domain is important as billions of people rely on email each day to serve their needs [34]. However, if information needs inspired by emails happen frequently, they could incur additional task-switching and disrupt users' email processing. Email clients are among the top applications that trigger mobile search, and users are likely to switch back and forth between email clients and searching applications in a short time [11]. Switching between applications and seeking information is time- and attention-consuming. Task-switching and interruptions longer than 15 seconds increase the likelihood of resumption errors when a person returns to the original task on a mobile phone [38]. Information-seeking via web search, which easily lasts over 15 seconds, thus could be harmful to a user's email efficiency. Email users have demonstrated the desire to have external information beyond the inbox integrated into future email clients [28]. If email clients could augment messages with the most commonly needed information, it would save people from needing to try to find it themselves. This would not only make it more efficient to get to the needed information, but could often provide information that some users were not even aware that they needed at a critical moment, such as special holiday hours for a store when viewing one of their promotional emails.

We built upon past research and methods to explore information needs (e.g., [13, 15, 32]), and focused on the nature of email-prompted information needs, people's strategies addressing these needs, and external factors that affect these needs. Specifically, we began this work with the following research questions:

- What types of external information do people need for different types of personal email messages?
- What strategies do people use to fulfill their email-prompted information needs?
- What contextual factors are associated with email-prompted information needs? Are there different types of needs people have at different times/days of the week? Or on a computer versus on mobile devices?

In order to answer these questions, we conducted two main studies plus a pilot and design evaluation. We started with eight pilot interviews to probe for specific examples of email-prompted information needs in order to better understand the domain. The pilot study helped us to create the materials for our main study, a two-week diary study with 49 participants to capture their email-prompted information needs as they occurred. This was followed with a survey, deployed to 733 participants to size some of the observations from the diary study in a broader population. With the diary study and survey's results, we concluded with a design concept evaluation with over 200 participants. Through these methods, our work makes the following contributions:

- We identify that there exist personal email-prompted information needs amongst a correlation of 9 types of information and 17 types of email, and further examine the most prevalent types of email-prompted information needs (e.g., Deal-Offerings, Advertising-Offerings, and Notification-Persons) both qualitatively and quantitatively.

- We identify contextual factors affecting users' email-prompted information needs, and users' strategies to address their needs.
- We conclude with design implications to support email-prompted information needs, and describe a proof-of-concept evaluation of designs based on these implications indicating widespread fit to user needs.

2 RELATED WORK

As background, we will review existing literature in two domains: general information needs and email use. This background helped us to understand the categories of information needs that people have in general, as well as the uses of personal email that might relate to some of these needs. We were unable to find literature that addressed specific information needs sparked by personal email content. We will describe this gap in the literature, which led us to our research questions.

2.1 Information Needs

The concept of "information needs" has a variety of definitions in previous work [13]. In this paper, we will use a broad definition of information needs from Dearman et al. [18]: "*an information need is as any information that is required for a task, or to satisfy the curiosity of the mind, regardless of whether the need is satisfied or not.*" This broad definition gave us the flexibility to explore a wide range of information that people may need while reading emails.

For several decades, researchers have explored information needs in other contexts, such as while web browsing, or while out and about in the world. Early work in online web search explored the types of information needs that users had while browsing the web. Chi et al. [12] explored "information scents" or patterns of browsing behavior that typified specific information needs. Broder [8] explored a taxonomy of different types of web searches that users performed, including informational, navigational, and transactional.

Recent work on daily information needs focuses on information-seeking in mobile contexts. Smartphones have become the most frequent devices that people use to access the internet, with 81% of Americans owning one [29]. Beyond ownership, time spent on mobile phones has dramatically increased. In 2018, users spent 190 minutes on average on their mobile devices per day, compared to only 52 minutes on the desktop internet [26].

Identifying types of information needs and contributing a taxonomy has been at the center of past HCI research on general mobile information-seeking [13]. These taxonomies provide theoretical bases for system designers to develop technical features supporting information needs. For example, in 2008 Sohn et al. conducted a two-week diary study to explore information needs on mobile devices [32]. This study identified 16 types of information needs. Around the same time, Church and Smyth conducted a 4-week diary study in 2009 and created 17 categories of mobile information needs [15].

Visiting the inconsistency in the taxonomy of information needs in past work, Church et al. synthesized these taxonomies and conducted another 4-week diary study in 2014 to provide a comprehensive taxonomy of daily information needs [13]. We were inspired by many aspects of their methodology, including interrupting participant at random times to capture a diverse set of information needs over several weeks. The taxonomy they proposed includes nine macrocategories and 30 micro-categories. The most common general information needs observed in their study included Finding (18%), Availability (15%) and People (12%). For consistency, we chose to utilize these categories in our own work to categorize the information needs that arose from email messages.

Beyond categorizing needs, another important area of research has focused on identifying contextual factors that affect an individual's information needs and information seeking strategies.

The environment and activities of an individual influences their information needs [3, 13, 32]. For example, a person arriving at a concert venue might have a need to pull up their ticket. Before arriving, they might have needed to know the address of the venue and how to navigate there on public transit. A rainy Saturday afternoon might bring needs for different types of information (e.g. movie times or museum hours) compared to a warm and sunny Tuesday morning.

In this past literature on information needs, emails were often seen as a carrier of information. That is, emails are studied as a medium to *fulfill* people's information needs, such as finding the time for a flight in the confirmation email [2, 10]. This research, for example, focused on finding the time or venue data for a concert (that are contained in an email body) or the dollar amount of a receipt (again, data contained in the email body but sometiems hard to locate). Reading emails, however, is an activity that could also *trigger* people's information needs beyond what is contained in the message body. Deng et al. found that mobile users often switched to applications including tools, social networking applications, and web browsers, after they used communication applications such as email [19]. Carrascal and Church studied users' application-switching when performing mobile searches [11]. They found that email applications ranked the fourth among applications that were launched multiple times for a search task. These past studies suggest that email could prompt users to look for external information and thus switch to other applications, but this has not been explored in detail, to the point where specific design recommendations could be made. Our work aims to tackle this question and propose implications for email system design to support this need for content beyond the message.

2.2 Personal Email Use

Since email was first invented in 1971, it has been used as a primary computer-supported communication channel. Early HCI work on email focused on helping users solve the information overload caused by emails [36, 37]. This body of literature focuses on understanding users' mental models in managing large numbers of personally-written emails, and leverages these models to develop technical designs that support email processing. A major focus of this work was on efficiency and on ensuring that users reply to personal messages in a reasonable amount of time.

Despite scholars' efforts to solve email's information overload problem, this issue still remains in current email use. Research on email in the past decade largely focuses on emails in professional and workplace settings. The reason emails cause stress and perception of low productivity is the information overload and switching costs when users are interrupted by incoming messages. [25] Categorizing, prioritizing, and replying to emails are often seen as necessary errands, while it also consumes users' cognitive resources. This line of work suggests that email in the workplace is positively associated with stress and perception of low productivity. HCI scholars have explored strategies and designs to support users in solving the information overload, but it is still an open problem. Additional literature has explored making it easier for people to write emails, such as Buschek et al.'s [9] exploration of suggesting multiple completions for text suggestions while composing an email.

In the literature on email use, personal email accounts have been less explored. While historically personal emails were used for interpersonal communication between individuals, recent studies have found this not to be true for the majority of messages received. In fact, an analysis of all non-spam messages delivered on a top personal email provider found that 95% of messages in a personal email account are system-generated messages from businesses and organizations, not personal messages written by friends or family [21]. Other research has found this to be true on other personal email providers as well. [4] Interpersonal communication with friends and family has largely moved from email to instant messaging [14], and personal email accounts are often filled with emails from corporations and organizations that users subscribe to [4]. That is, personal email

accounts have transitioned from an interpersonal communication tool to a business-to-customer (B2C) information hub for a user [22, 23].

This new role of personal email as a commercial information hub requires us to revisit the design of personal email clients that have assumed the previous interpersonal communication focus. Previous work, such as Yahoo Mail 6, have changed the way that emails are organized, having pre-made Views for receipts, deals, travel itineraries, and attachments [5]. Recent startup email services, such as hey.com, have adopted similar organizational tools. Some of these services currently provide ways to summarize emails or to surface important information, such as a flight departure time, or a package tracking number, at the top of a message. However, emails that are primarily from businesses and organizations communicating to consumers might inspire a variety of additional information needs that go beyond the email itself, and require information from external services to be presented to the user. This prompted our research into the information needs that are sparked by reading email messages in personal email accounts, a task that billions of users around the world perform each day.

3 METHODS

To understand email-prompted information needs, we conducted a mixed-methods study that consisted of two phases. We started with a pilot study consisting of a series of exploratory interviews to familiarize ourselves with users' information-seeking behavior while reading emails. The initial themes from this pilot informed Phase 1, a two-week diary study conducted with 49 participants who cataloged email-prompted information needs that occurred throughout those 14 days. We then sampled 18 out of the 49 participants for follow-up interviews to get a deeper understanding of their diary entries. In Phase 2, we deployed an online survey, which was informed by the results from Phase 1, to examine the prevalence of our diary study results with a broader sample of respondents.

All research was conducted during July - August 2020. We note that the study occurred during the Coronavirus pandemic, but at a time after many US states had reopened the majority of their economy. The final week of the diary study also coincided with the return of major league sports with both Major League Baseball and the National Basketball Association resuming games. While this context may have affected the types of emails received or opened (e.g. fewer event-related messages were relevant), most participants were working and visiting stores during the time of the study and still had the same types of bills to pay.

All research described in this paper followed our institutional practices for research with human subjects and sensitive data and was reviewed with research leadership before the study was conducted. In particular, participants had full control over the emails that they shared with us, could skip questions or withdraw from the study at any time, and were paid typical industry-research rates for their participation (e.g. US$100 for a diary study and followup interview). After collection, all data was anonymized and cannot be tied back to a specific individual.

3.1 Pilot Interviews

We conducted a series of eight pilot interviews to familiarize ourselves with the domain of email-prompted information needs and to prepare us for designing the materials for later phases of this work. Participants who used a personal email account at least a few times per week were recruited to participate in online, moderated interviews on usertesting.com. Participants ranged in age from 18 to 53 and six were female. Interviews averaged 30 minutes in length, were conducted remotely, and were video recorded for analysis.

We began by asking background questions related to the participant's email use to better understand the providers that they used and the types of messages that they received in each account. We then asked participants to recall a recent information need sparked by an email message. We

probed about that email's details, the information they looked for, how they looked for it, and the context in which they were reading this email. The primary purpose of the pilot study was to familiarize ourselves with the domain, as we knew that a retrospective interview-based study would not capture the breadth of all information needs, as many are easily forgotten. We would then go on to use this data to inform the design of our diary template.

We collected 29 instances of email-prompted information needs from the eight pilot participants. All participants were able to recall email-prompted information needs that happened in the past few days, if not on the day of the interview, highlighting that email-prompted information needs happen frequently throughout the week. We also identified four strategies that participants used to fulfill information needs: clicking links in mail, searching keywords online, directly switching to corresponding websites or applications, and visiting social media platforms.

We used the knowledge gained from these pilot interviews to inform the design of the diary template and analysis in Phase 1's diary study. Since email-prompted information needs were frequent, a diary study of 14 day duration was deemed sufficient to collect many examples from each participant. Also, the strategies users had for finding information were included as a question for each diary entry as explained below.

3.2 Phase 1: Two-week Diary Study

With the background from the pilot study, we moved on to the main part of our study which consisted of a two-week diary study with followup interviews. We followed the best practices for conducting diary studies as outlined by Consolvo et al. [16] including asking for times when participants were available for diary reminders, using SMS to send reminders, and quickly following up with participants who were not providing entries.

3.2.1 Diary Study.

Participant Recruitment. We recruited a broad set of 49 diverse participants for this study utilizing a large database of people throughout the United States who had previously volunteered to be research participants that was managed by the authors' organization. Participants ranged in age from 18-65 (median 37), 26 (53%) were female, and 63% of participants had completed a college degree. They resided in all regions of the United States and all used a personal email account regularly.

Participant Onboarding. Participants signed a consent form and received an onboarding email about the study, including a three-minute video that provided an overview of the study as well as written details about study requirements, incentives, and termination policies. We also described that we were interested in instances of which participants looked for *external information beyond the email messages* in our instructional video. We specified in the email that participants were expected to submit diaries at least 10 of the 14 days to be fully compensated $50 for their participation (note that a valid diary entry could state that there were no email-prompted information needs on that date). If they submitted diaries for five to nine days, they would receive $25. Participants who were invited to participate in the final interviews received an additional $50 upon completion.

We asked each participant to specify the times that they were willing to receive diary reminders, encouraging broad ranges when they were typically awake. Over the course of the study, we would send reminders at random times each day so that we could understand recent email-prompted information needs in different contexts, but did not want to disturb them during hours they normally slept or could not handle an interruption. Participants were asked to check off their availability in 2-hour time windows (i.e, 8-10am, 10am-12pm, and so on until 8-10pm) each day of the week.

Data Collection. The research team texted participants a reminder to submit a diary entry each day during the 14-day study at a random time in their availability window. The reminder included a link to the diary template (an online survey), and participants were asked to submit a diary as soon as possible after receiving the reminder. Reminders were semi-manually managed by the first author using a Python randomizer that scheduled reminders at random times taking participants' availability into account. Each hour from 8am Eastern Time to 10pm Pacific Time we checked if a participant snoozed the reminder, then ran the randomizer again to schedule another reminder for the participant on that day.

In the diary form, participants were first asked if they had checked their email and looked for related information on that day. If they chose "*Yes, I've checked my email and looked for more information related to a message*" they would proceed to fill out a diary entry; Participants could also choose "*Yes, I've checked my email but I didn't look up any related information today,*" which we also considered as a valid diary entry but did not trigger followup questions. Finally, participants could also snooze the reminder by selecting "*No, I haven't checked my email today. Please remind me again later.*" which would trigger a reminder at another random interval before the end of the day as we described in the prior paragraph.

Once participants stated that they had looked for related information that day, they were asked to "*Describe the email that you were reading,*" "*Describe the additional information you searched related to this message,*" and "*Describe the reason you looked for this information.*" Participants were able to use up to 100 characters to respond to these prompts. Our diary study aimed to understand participants' email-prompted information needs, including the contextual factors of when these needs happened. Therefore, it would be better if participants could respond to the diary form as soon as they received the reminders so that they could recall the contexts clearly. We made the character limit to reduce participants' cognitive load so that filling a diary was not so overwhelming that they wanted to postpone.

Participants were then asked to categorize the email they were reading. The email types provided were derived from an expert content analysis by trained editors on thousands of human-readable messages from an internal dataset and have been used extensively in our organization in the past. This list included 16 email types, for example, Deal, Bill, Receipt, or Personal Correspondence. The full list can be seen in Fig. 3, including some tagged Unknown where no category was provided or could be determined based on other aspects of the diary entry. The email taxonomy was developed internally in our institution and is used in production with hundreds of millions of users and billions of emails per day. It was created by having skilled editors manually classify thousands of human-readable email messages that users opted-in to sharing with the organization, inductively building the taxonomy. Participants were allowed to check multiple categories if they felt the email belonged to more than one. Participants were also allowed to specify an Other category to provide more detail on the type of message. Upon review of the participant categorizations by the first author, some discrepancies were found, and the first author manually reviewed and updated the categories for all diary entries to be consistent across participants using data from the open-ended responses to choose the most appropriate category. We also asked which device they had used for reading the email, and which device was used to meet the information need from a list of: "smartphone", "tablet", "laptop/desktop", and "other (please specify)".

Finally, we asked participants about the strategies they used to find the information: "searching with related keywords," "directly visiting a website or opening a related app," "clicking on links in the email," and "looking up on a social media platform", and "other (please specify)". These four strategies were derived from the pilot interviews. Participants were also asked to report when the need happened through an open-ended prompt. Lastly, participants were given an open-ended

prompt to specify any other comments they would like to share. Each diary entry was designed to be completed in less than five minutes.

The first author skimmed the newly collected diary entries every day to identify invalid entries in which participants misunderstood the definition of email-prompted information needs (e.g. if they were looking for information *within* an email message and not from an external source). The first author then contacted participants who submitted this type of invalid entry and explained the definition during the diary study.

Data Analysis. We excluded duplicate diary entries as well as any invalid entries as described in the prior paragraph. In total, we received 659 valid diary entries (out of 825 submitted), an average of 13 per participant. This set included both diaries with email-prompted information needs and diaries without email-prompted information needs.

To code the types of information needed, we used a taxonomy from past literature on mobile information needs [13]. This taxonomy included nine macro-categories of information, which further covers 30 micro-categories. The primary author coded all the information needs and met with the second author frequently to discuss the categorization.

When we mapped the email genre and information types to a two dimensional table, the table was very sparse, as we present in Subsec. 4.2, which made statistical techniques such as regression, impractical for our data analysis. Thus, we will focus on descriptive statistics for our diary study's results.

3.2.2 Follow-up Interview.

Participant Sampling. After we completed the diary study, the authors reviewed participants' diaries and adapted purposive sampling to select half of the participants for the follow-up interviews. We intentionally selected participants who provided entries that were also themes from the entire sample, or those who had specific needs that we felt could best be assisted by new features of an email client. We invited 26 participants (14 women) to the follow-up interviews and 18 of them participated (10 women). These participants ranged in age from 18 to 65+ (median 41). Among the 18 participants, one had a high school degree, four had some college (including associate degrees), 11 had college degrees, and two had post-graduate degrees.

Interview Procedure. The follow-up interviews were 45 minutes in length and conducted remotely through Google Meet. In each session, the interviewer shared their screen with the participant and presented all of the diary entries that they submitted. The participant was first asked to skim the entries and select an entry that stood out to them and then describe that situation in more detail. After the participant described an entry of their choice, the interviewer asked questions to prompt for more detail, such as the reason they needed the information or the context in which they looked for the information. The interviewer then highlighted diary entries of interest to the research team (decided on in advance) and prompted participants to provide additional information about these situations. The interviewer repeated this process until the end of the sessions. In total, we were able to interview 18 participants about 74 entries (an average of about four entries per participant).

Data Analysis. We employed a thematic analysis to inductively analyze our interview data. The first author analyzed recordings to identify quotes of interest. We focused on factors behind participants' information-seeking behaviors, e.g., why they looked for the specific information, how they looked for the information, and what external factors affected their information-seeking. The first author then grouped the quotes to generate preliminary themes central to our research questions. The first author and the second author met three times a week to revisit the data and revise the identified themes. We iterated this process until no new theme was generated.

	Group	N
Gender	Man	74
	Woman	148
Age	18-29	23
	30-44	40
	45-60	60
	60 and above	99
Annual Income	$0-$49,999	72
	$50,000-$99,999	64
	$100,000-$149,999	32
	$150,000-$199,999	8
	$200,000 and above	10
	Not available (prefer not to answer or blank)	36

Table 1. Demographic information of SurveyMonkey participants (N=222).

3.3 Phase 2: Online Survey

Study Design. Phase 1 explored email-prompted information needs in a relatively small population of 49 participants. In Phase 2, we sought to quantify email-prompted information needs in a much broader population. We limited survey fatigue by focusing on the most promising email types. We first included the top three email types from Phase 1: *Notification*, *Deal*, and *Newsletter* messages. We also included two additional email types: Bill and Event in the questionnaire as we saw specific needs around these types emerge in Phase 1. We believe that the frequency of these two categories was lower in the diary study due to the short duration (two weeks when most bills arrive monthly) and the context of COVID-19, where many events were not occurring.

We designed an online survey to study the *topics* of these email types and *content* of the corresponding information needs. For each of the five email types, the survey started with this prompt, "*Please think about the last time that you were reading a [one of the five email types] email and you looked for information beyond what was contained in the message. What was the topic of the message?*" For example, for a Notification message we included a few different topics for Notification emails, such as account changes, banking updates, or shipment notifications. Participants could also specify that they were not able to recall any experiences related to this email type. We then asked participants about the information content they looked for. Take Notification messages again, the information content included users' account information, receipts, or shipment details, etc. We repeated these questions for all five email types. The full list of email topics and information content are presented in Fig. 12 - Fig.16. We drew these email topics and information content from the set of all emails mentioned in Phase 1's data for the each of the email categories in the survey.

Participant Sampling. We collected survey responses from two panels as past research suggests that different survey platforms have distinct characteristics in their panel participants [6]. To diversify our target population, we collected responses through the SurveyMonkey Audience panel and on Mechanical Turk (MTurk). Surveys were targeted to a US general population on SurveyMonkey and to a US audience with 97%+ acceptance rates on MTurk. As found in previous comparative studies (e.g. [6]) these methods provide responses typically within 5% of ground truth on a wide variety of demographic and behavioral measures.

	Group	N
Gender	Man	327
	Woman	181
	Prefer not to answer	3
Age	18-24	32
	25-34	227
	35-44	139
	45-54	72
	55-64	26
	65 and above	15
Educational Background	Less than a high school degree	1
	High school degree or equivalent	47
	Associate degree	55
	Some college but no degree	74
	Graduated from college	240
	Some graduate school	29
	Completed graduate school	65

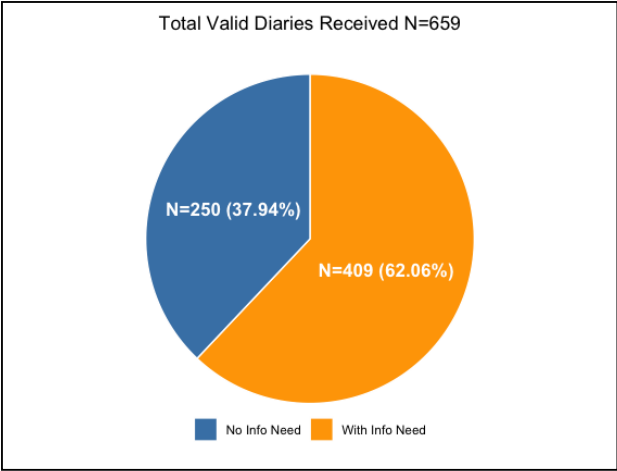Table 2. Demographic information of MTurk participants (N=511).

Fig. 1. Proportion of diaries with needs and without needs. More than 60% (N=409) of the valid diaries (total N=659) reported an email-prompted information need. This suggests that on average, participants had email-prompted information needs for two out of every three days.

Data Analysis. In total we collected 733 survey responses (SurveyMonkey N=222, MTurk N=511). Table 1 and Table 2 present participant demographic information. Participants ranged in age from 18-65+ (median 52.5 for SurveyMonkey participants; 30 for MTurk participants) and 42% were women (N=329). We did not include questions for participants' demographic information. Their demographic information was recorded automatically by SurveyMonkey and MTurk. We leveraged descriptive statistics to explore the survey results.
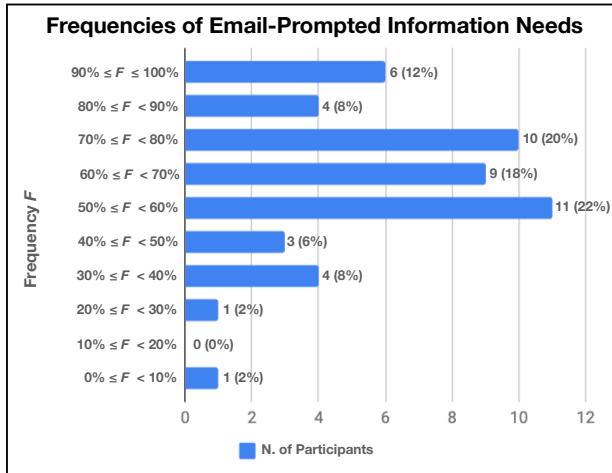
Fig. 2. The values in the bar represent the number of users in that range, for example 11 participants had information needs between 50-60% of days in the study. Participants frequently had email-prompted information needs, with 80% of participants having needs on at least 50% of days.

4 DIARY STUDY RESULTS

After examining the collected diaries, we found 659 valid diary entries. As shown in Fig. 1, 409 of the diaries reported email-prompted information needs, which suggested that on average, personal email users have email-prompted information needs on nearly 2 out of every 3 days. Fig. 2 further shows the distribution of days with email-prompted information needs across participants. 80% of our participants (N=40) had email-prompted information needs on at least 50% of days.

This data demonstrates that email-prompted information needs happen quite frequently, and that a large proportion of personal email users have email-prompted information needs on the majority of days. Both of these findings suggest that there is an opportunity for a design space of solutions for helping users with their email-prompted information needs within an email client.

4.1 What Emails Trigger Email-Prompted Information Needs?

Next, we will explore the types of email messages that participants reported that sparked an information need. Fig. 3 presents the distribution of email types reported in the diaries, showing the number of diary entries with each email type. Among all of the email types, *Notification*, *Deal*, and *Newsletter* were the top three categories that led to email-prompted information needs, comprising 47% of all diaries with a need. We will focus on these top three categories for our analysis.

A *Notification* message is sent to the recipient based on an established membership, subscription, alert preference, or other relationship the recipient has with the sender. Notifications are often specific to the recipient's preferences/interests, opted into, or prompted by previous activity of the recipient. These emails typically serve to alert the recipient of activity or changes they may want or need to know about. Notifications accounted for 20% of the email-prompted information needs in the diaries, and 71% of participants had needs associated with Notifications during the two weeks of the study. Examples of Notification emails that participants reported included notifications from online stores (package shipment, membership updates, etc.), financial organizations (balance alert, quarterly investment updates, etc.), and social media (connection invite). For example, P9 described reading a notification from 23andMe notifying her about new relatives. P9 was adopted
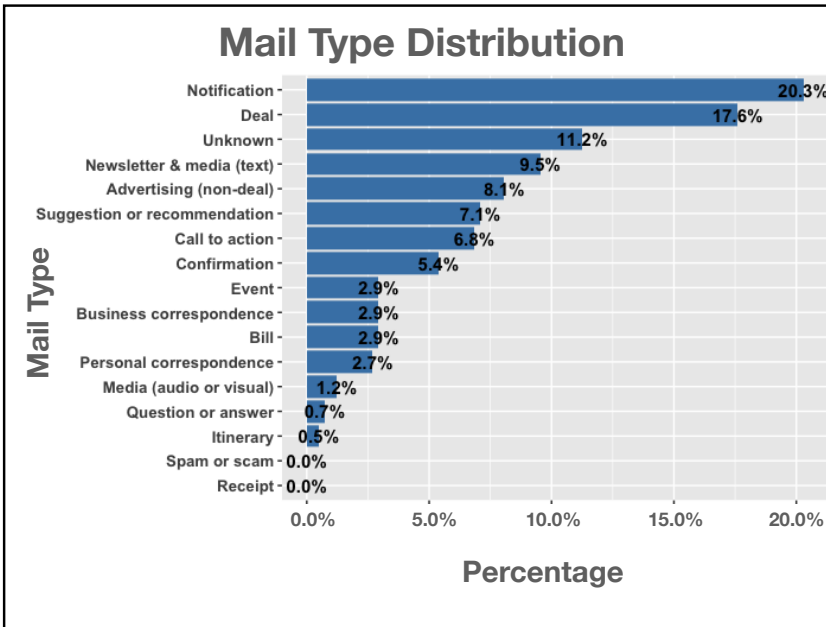
Fig. 3. The distribution of email types with information needs that were reported in the diaries. "Unknown" refers to diary entries that lack of details and thus were not able to be classified.

and interested in identifying relatives, so she visited 23andMe after reading the message to find information about the new relatives.

Deal emails cover messages that provide money-saving offers. These offers are often subject to a time frame, location, group of people ("subscribers only"), or only accessible with the use of a promo code or with a minimum purchase amount. Deal emails accounted for 18% of the email-prompted information needs in the diaries, and 61% of participants had needs associated with Deal mails during the two weeks of the study. Examples of Deal emails included advertisements from big-box retail chains (BestBuy, Costco, Safeway), apparel retailers (H&M, Nordstrom), restaurants, and airlines. Some of the Deal messages came from deal sites such as Slickdeals or Groupon. P47 talked about an email from Slickdeals providing coupons for Fruit of the Loom products on Amazon. To determine whether the deal was good, P47 went on Slickdeals to look for other customers' comments on the deal.

Newsletter & Text Media (Newsletter for simplicity) includes all types of text-based media, although some instances may include multimedia content. This email type not only included news articles but also any kind of text-based articles such as blog posts or community updates delivered via email. Newsletters accounted for 10% of email-prompted information needs in the diaries, and 37% of participants had email-prompted information needs associated with Newsletter messages. Examples of Newsletters in the diaries included news from a wide variety of news sources, such as CNN, CBS News, Yahoo News, Wired, or local newspapers. The messages covered a wide range of topics, such as local news, sports, finance, and technology. P37 subscribed to Morning Brew's daily newsletter. In one of the diaries, she reported that she was reading Morning Brew's news digest about the investigation of four tech companies. She then went on Morning Brew to read a full news article reporting on the case of Amazon, and also searched for several subjects that she did not understand in the article.
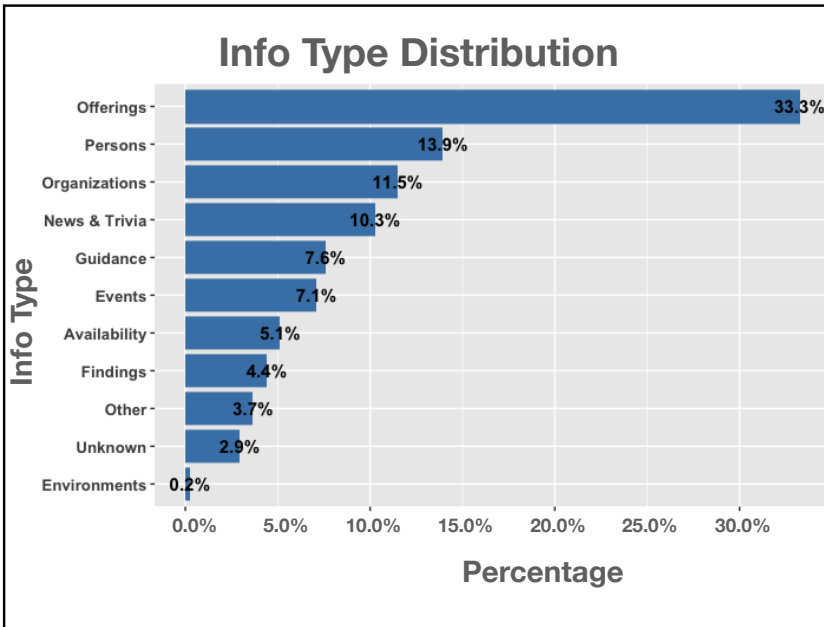
Fig. 4. The distribution of information types reported in the diaries. "Unknown" refers to diary entries that lack of details and thus were not able to be classified.

These were the types of emails that sparked information needs, but what information was searched for? We now move on to the types of information that users went looking for after reading an email message.

4.2 What Information is Needed?

Fig. 4 presents the information types reported in the diaries. As mentioned above, we followed the taxonomy of Church et al. [13]. The value of each bar refers to the percentage of diaries with that information type. Among all the information types, the top three were *Offerings*, *Persons*, *and Establishment & Organizations* (we use Organizations to refer to this type of information for simplicity for the rest of this paper).

The Offerings information includes details of an offered product or service (e.g. quality, prices) and people's opinion about the offered subject (e.g. customer reviews) [13]. Offerings information comprised 33% of the needed information after viewing an email. Examples from the diaries included information about details of the products/services on sale (e.g., discounted prices, spec of a product, alternative choices of products) and customer comments on the offered subjects (e.g., review on a product/service). For instance, P2 received a email from a local Chinese restaurant promoting a new item. P2 had never been to the restaurant, so looked for their menu and reviews of the food.

Information of Persons refers to information that is about a specific person, pet, or oneself, including the person's well-being, state of an asset, contact information, appointments, and memories [13]. 14% of needed information was classified as Persons. Examples from the diaries included financial status and health information of the participant, general background of a public figure, and friends' status on social media. For instance, P26 stated that he looked into three profiles on LinkedIn because LinkedIn notified him about their visits.

Information of Organizations is defined as information related to an organization, a group, or a society, which includes the properties of an organization, policies and laws enforced by an
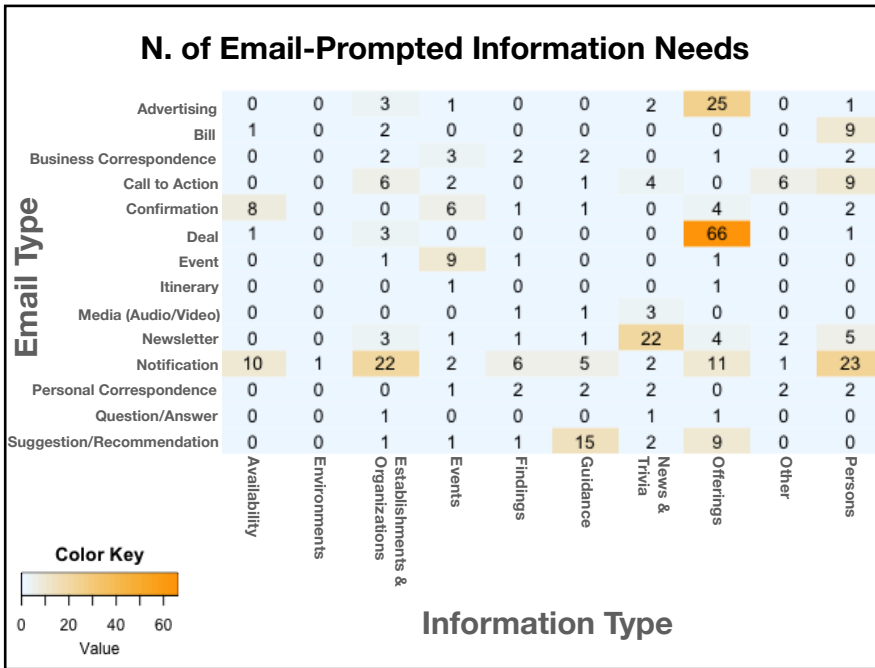
Fig. 5. The number of each email-prompted information needs reported in the diaries. Note that emails of Unknown type were excluded from the heatmap.

organization, and an organization's contact information [13]. 12% of the information reported in the diaries belong to Information of Organizations, including organization policies (e.g., schools' COVID policies, job positions, scholarship application requirements), membership policies, and contact information of a store. P6 reported her experience looking into a job position's policies after she received a notification from her school's career center.

4.2.1 Email-Information Pairs. We will now explore the combinations of email types and the types of information that was sought out, as shown in Fig. 5 and 6. Fig. 5 displays the number of total diary entries that reported each email-prompted information need, while Fig. 6 displays the number of participants who reported each email-prompted information need. *Deal-Offerings* was the most reported email-information need (N=66, 16% of all entries) and was reported by 29 participants (59%). The second most common was *Advertising-Offerings* (N=25, 6% of all entries) and was reported by 19 participants (39%). While the third most commons was *Notification-Persons* (N=23, 6% of all entries) which was reported by 16 participants (33%).

The following are specific examples of email-information needs for common pairs:

- Deal-Offerings: P35 received an email from Chewy providing a discount on pet food that she liked. She went on Petco to look for the same pet food's price to compare.
- Newsletter-NewsTrivia: P12 was reading the news digest email from Wired. He was interested in an article about scientists studying an ancient virus. He visited Wired to read the full version of the article. He also searched other news sources to compare with the article from Wired.
- Notification-Organization: P9 received a notification from Sephora informing her about her upgraded membership. P9 then went on Sephora's website to look for the policies about her new membership level.

N. of Participants with Certain Email-Prompted Information Needs

Email Type	Availability	Environments	Establishments & Organizations	Events	Findings	Guidance	News & Trivia	Offerings	Other	Persons
Advertising	0	0	2	1	0	0	2	19	0	1
Bill	1	0	2	0	0	0	0	0	0	7
Business Correspondence	0	0	2	3	2	2	0	1	0	2
Call to Action	0	0	5	2	0	1	3	0	5	4
Confirmation	8	0	0	5	1	1	0	4	0	2
Deal	1	0	3	0	0	0	0	29	0	1
Event	0	0	1	6	1	0	0	1	0	0
Itinerary	0	0	0	1	0	0	0	1	0	0
Media (Audio/Video)	0	0	0	0	1	1	3	0	0	0
Newsletter	0	0	3	1	1	1	12	3	2	5
Notification	5	1	14	2	6	5	2	8	1	16
Personal Correspondence	0	0	0	1	2	2	2	0	2	2
Question/Answer	0	0	1	0	0	0	1	1	0	0
Suggestion/Recommendation	0	0	1	1	1	11	2	7	0	0

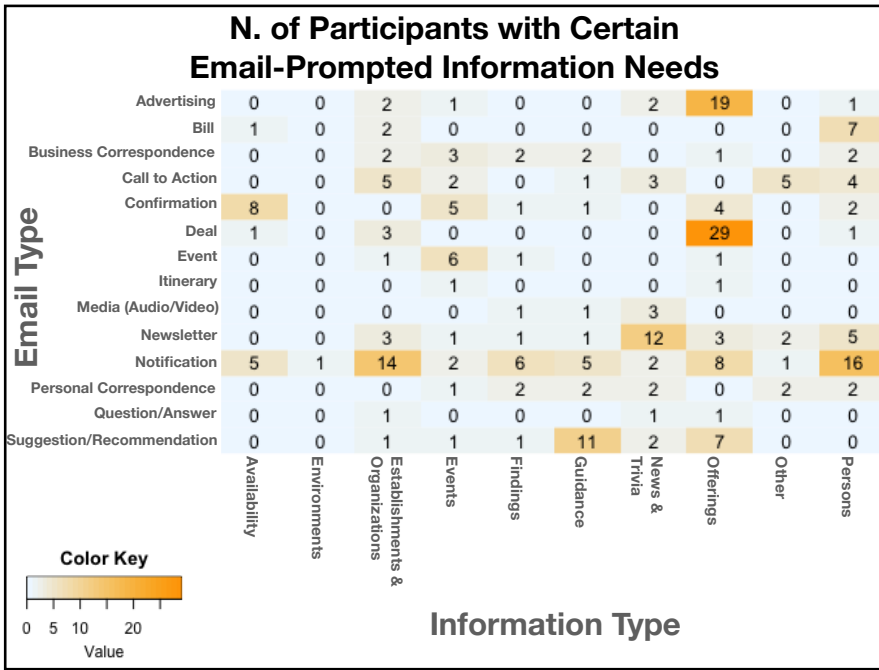**Information Type**

Color Key

0 5 10 20
Value

Fig. 6. The number of participants who reported at least one time of such email-prompted information need. Note that emails of Unknown type were excluded from the heatmap.

	OR	95% CI
(Intercept)	1.714*	[1.137, 2.625]
Tues.	1.267	[0.692, 2.333]
Wed.	0.936	[0.523, 1.676]
Thurs.	1.479	[0.810, 2.721]
Fri.	0.831	[0.464, 1.485]
Sat.	0.510*	[0.282, 0.915]
Sun.	1.003	[0.548, 1.836]

*** $p < .001$; ** $p < .01$; * $p < .05$; . $p < .1$

Table 3. Logistic regression comparing email-prompted information needs on days of a week (0=no email-prompted information needs, 1=with email-prompted information need; Monday used as the reference).

- Notification-Person: P30 received a notification email from Mint, notifying her that a new credit score was available. She then opened Mint to check the actual score.

4.3 When Do Users Address Email-Prompted Information Needs?

To answer our research question around temporal patterns of information needs, we analyzed two temporal factors - day of week and hour of day. Fig 7 presents the distribution of diaries with email-prompted information needs from Monday to Sunday. On each day of the week approximately 60% of participants reported email-prompted information needs except for Thursday and Saturday. Thursday had the highest percentage of email-prompted information needs (72%), while Saturday had the lowest (47%). We employed a logistic regression model to examine the differences in number of email-prompted information needs of the seven days. Using days of a week (categorical) as an
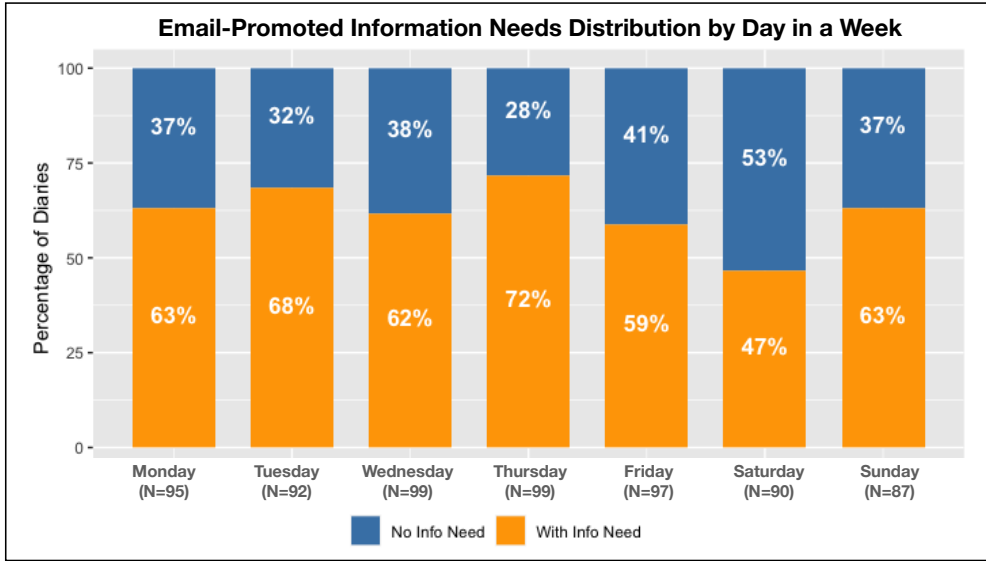
Fig. 7. The distribution of diaries we received on each single day of a week. Thursdays had the highest number of email-prompted information needs, while Saturdays had the lowest.
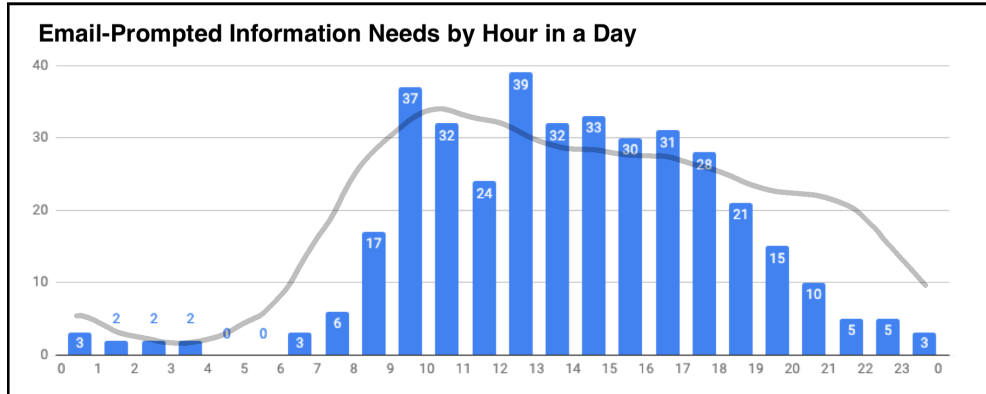

Fig. 8. Hourly email-prompted information needs (bars) compared to email usage times (line) from [33]. Each bar represents the number of diaries. Note that 29 diary entries are not included because they did not specify the exact hour.

independent variable and with email-prompted information need or not (binary) as a dependent variable, the result (Table 3) suggests that email-prompted information needs on Saturdays were significantly lower than the other six days ($p < .05$).

Fig 8 illustrates the distribution of participants' email-prompted information needs by hour of day. More than 80% of email-prompted information needs were addressed during the morning or afternoon hours (9am to 6pm). Two peaks of email-prompted information needs occurred in the early morning (9-10am) and early afternoon (12-1pm). This pattern is consistent with times of reading email (the line on the graph, reproduced from [33]), which is also at its daily peak from 9am to 1pm.

However, while email reading remains frequent in the evening, we did not see a similar peak of email-prompted information needs in the evening. This suggests that when people check emails in

the evening, they are less likely to look for information related to their emails, perhaps because they are more focused on the family or evening activities such as preparing dinner.

In the follow-up interviews we asked participants why they addressed their email-prompted information needs at the times they specified. We also probed if they addressed the needs right after they read the message or postponed their needs to a later time. We identified five factors, which can be grouped into contextual and informational, that affected whether participants addressed their email-prompted information needs right away.

4.3.1 Contextual Factors. We identified three contextual factors that affected the timing for participants to address their email-prompted information needs.

Time between checking email and the event. While reading email, at times participants encountered a message that led them to an information need that they wanted to address in the moment. If these tasks were urgent or participants had the time, they went on to look for the needed information immediately. For example, P30 received a reminder for a webinar 10 minutes before it started. She did not know who the speaker was and hesitated to join. She searched for the speaker's information right away to decide whether the webinar was worth participation.

On the other hand, if the task associated with the needed information was not urgent, participants were likely to postpone their information-seeking. P49 discussed receiving a notification for her son's doctor appointment. Because the appointment was a few days later, P49 did not look for more information about the appointment right away, but waited until the day before the appointment to visit the patient portal to read the instructions for the visit.

Information not associated with the current activity. Whether participants were busy on other tasks affected when they addressed their email-prompted information needs. As mentioned in the previous section, early morning is one time that people are most likely to check their emails. However, early morning is also a time full of daily errands. Participants described cases in which they checked their email in the morning and had information needs sparked by specific messages, but they needed to switch back to tasks such as their work, school, or house errands. For instance, P39 received a message featuring a sale from an online store where he bought daily planners. However, it was a weekday and he was already working when he received the email. While he opened the email right away, he did not look into the sale's details until he had more time later on that day.

However, some were more flexible with their time. When P35 received a notification from Zillow that listed newly available homes, she searched for the information about the houses and viewed street view images right after she read the message. When being asked why she looked into the information right away, P35 stated that under the COVID-19 outbreak, she was not able to go anywhere so she had time to check it. This gave her spare time to look for information that she wanted, despite the fact that the information needed was not urgent.

Information needed by others. In some cases, whether the information was needed urgently is not fully determined by the recipient. Instead, it was related to other stakeholders. When the recipient needs to share the information to someone else, then collaborating with the stakeholder becomes one factor affecting the timing of addressing their email-prompted information needs. For example, P9 received a USPS notification for an upcoming package. She read the message and checked the shipment right away because she would not be at home that day. She then shared the estimated arrival time with her sister, so that her sister could pick up the package for her.

4.3.2 Informational Factors. Sometimes, it was the way a user had to access information that led to when the need was met. We identified two factors related to information access.

Information Source Type	N	Examples
Online Store	140	Megastore (Amazon), Airlines, Restaurants
News Media	36	Apple News, CNN, Yahoo
Financial Application/Website	28	CapitalOne, Mint, StateFarm
Search Engine	25	Google
Social Media	22	LinkedIn, NextDoor, Twitter
Business Website	16	Google Services, AT&T
Non-business Organization Website	15	Local library websites, NPO websites
Utility Application/Website	15	Google Maps, survey platforms, Zoom
Documents	13	Files in Google Drive; Local files
Health/Medical Website	9	23andMe, Kaiser Permanente, some clinics
Employment Website	8	Indeed
Event Website	6	Evite, some events' websites
Personal Pages	6	Oprah.com
School Website	6	N/A
Shopping Reward Website	6	Groupon, SlickDeals
Delivery or shipment website	4	Fedex, USPS
Housing Website	4	Apartment websites; Real estate websites
Tutorial Website	4	AllRecipies
Inbox	3	N/A
Political Website	2	dwspac.com
Unknown	41	N/A

Table 4. The external information sources that participants reported visiting in their diaries.

Difficulty to find and access the information. The more effort that was needed to find or access the desired information, the more likely recipients were to postpone the search for it. For example, P47 was reading a Bill message for her credit card. She did not look into the detailed bill on her online bank right away because she had a hard time recalling her account username and password. She left this need to the evening, when she had spare time to recover her account information.

Limitation of the information due to external factors. Lastly, the information needs might be met quickly if the information itself is time sensitive. This was especially associated with Deal messages which provided time-limited discounts. P37 was reading a deal email from Nordstrom. She clicked on the link in the message and visited Nordstrom's website to find more information about the products on sale immediately after she read it. She did this right away because she knew that the products on sale could change or sell out quickly.

4.4　How Do Users Address Email-Prompted Information Needs?

We have now explored the types of emails that spark information needs, the types of information that is desired, and contextual factors. But how do users go about satisfying these needs? Table 4 presents the information sources that users reported in their diaries. The Unknown category includes diaries that reported information sources without specifying details. For example, there was a diary entry describing the email content as: "*I confirmed my account for a specific website.*" The participant described the information that he looked for as: "*I had to confirm my account; once I did so, I visited the site afterwards*" in the diary entry.
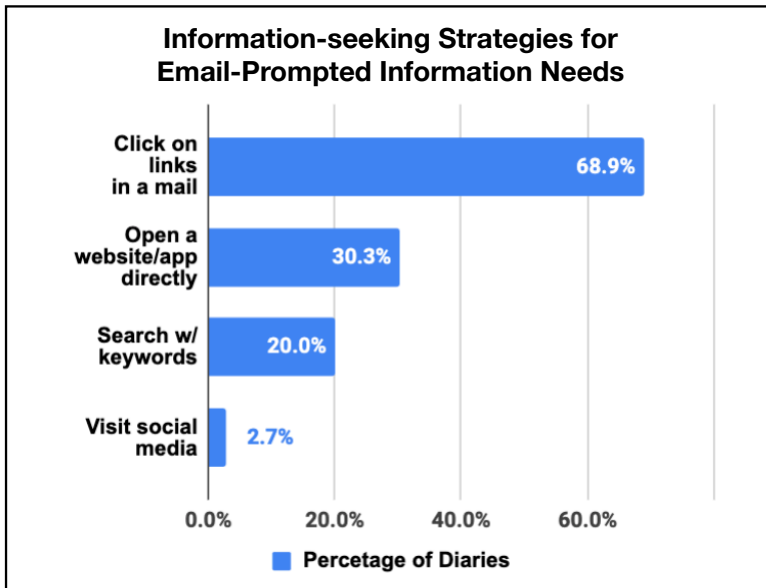
Fig. 9. Participants' information-seeking strategies to address their email-prompted information needs. 69% of the information needs were addressed by clicking on links in a mail. Values add up to more than 100 % because a diary may specify multiple strategies.

Fig. 9 presents participants' strategies to find their desired information (Note that a user could specify more than one strategy for each email-prompted information need). The 409 diary entries that contained email-prompted information needs included 499 strategies: 282 entries (69%) reported that the participant tried to address their email-prompted information needs through clicking on a link in an email; in 124 entries (30%), the participant opened a website/application directly; in 82 entries (20%) they searched on the web with keywords; and in 11 entries (3%) participants reported visiting social media sites to look for related information.

4.4.1 Reasons for Clicking on the Links. Most emails contain links to direct recipients to information they might need when reading the message. This is often the easiest way to address an information need. From the interviews, we identified three reasons that participants relied on the links in the message body to look for their needed information.

Little effort for information-seeking. Participants stated that clicking on links was the "easiest" and most "convenient" way to find and access the needed information. Links in the email typically direct readers to pages or applications that contain information directly associated with the message contents. When the needed information was directly related to the message, following links in the email was the most straightforward way for users to reach the information. For example, P49 shared an experience reading a Deal message from Texas Roadhouse and wanting to look at the menu. She clicked on the link in the message which went to the restaurant's website, from which she could navigate to the menu. She said clicking on the link was the most straightforward way to find the menu.

Needed information is secured or private. In some cases, the needed information might be private to the recipient, and thus participants felt that only by following the links in the email could they access the secured information. P47 received a reminder for her son's appointment with the doctor.

She needed to click on links in an email to visit the patient portal to read instructions for pre-appointment preparation. When asked about why she clicked on the links to find the information, she stated that "*I believe that the information was only accessible through the link because of privacy and security reasons.*"

Trust in the sender. Email recipients' trust in the sender also plays a role in participants' information seeking strategies. A recipient is likely to click on links in an email if they trust the sender. P14 talked about reading a Deal message from Best Buy. He stated that "*I always click on the links from Best Buy because I trust them. The link will bring me to pages that provide the most accurate information.*"

4.4.2 Reasons for Using Other Strategies. When the information needed is broader than what is contained in the email's direct content, users would rely on strategies other than clicking on links to look for their information, such as searching on the web or using a specialized application.

Looking for information in-depth. Mail recipients might need information that is not provided by the message, or through links in the message. In these cases participants needed to look for the information by themselves. Often, a need for in-depth information, information that is related to the message topic but contains more details on the topic, is sparked by the message. Participants frequently looked for in-depth information by searching for the information using search engines or other dedicated websites or apps.

P35 shared a few cases when she looked for in-depth information when she received notifications for newly available homes for sale. She said that websites she subscribed to, such as Zillow or her real estate agents, did not provide in-depth information such as the street views and neighborhood information on their websites. Thus P35 always visited another real estate platform to look for in-depth information of these newly available homes when she was notified.

Looking for information in-breadth. Similar to looking for in-depth information, some participants looked for in-breadth information, information that was related to the message contents but was broader than the email's scope. For example, P51 reported email-prompted information needs associated with politicians' fundraising mails in six different diary entries. For these messages, he wanted to know the politician's past news from other perspectives, so he searched for this person on Google to find information from different points of view. This in-breadth information supported his decision to make a donation to specific politicians or not.

Distrust in the sender. As mentioned in the previous subsection, trust in the sender pushed participants to follow links in an email for more information. In contrast, distrust in the mail sender prevented participants from following the links. In these cases, participants might search for information that is related to the mail message but from other sources that they felt comfortable with. For example, P12 shared an experience about receiving mail from GlobalZero, including an article mourning for a celebrity. He was interested in knowing more about the news, but he did not remember subscribing to GlobalZero and was thus not comfortable clicking on the links in the email to read the full article. He searched about the news using search engines and searched GlobalZero to make sure it was a legitimate organization. This is similar to behavior observed by O'Donnell and Cramer [27] for online advertisements where participants did not always trust the link and were afraid of malware or phishing sites.

Accessing information through the link requires too much effort. Besides looking for more in-depth and in-breadth information, participants described that the destination page or application is not always convenient to use. In these cases, seeking information following the links in a message requires too much of the recipients' effort. Participants might instead visit the associated website or
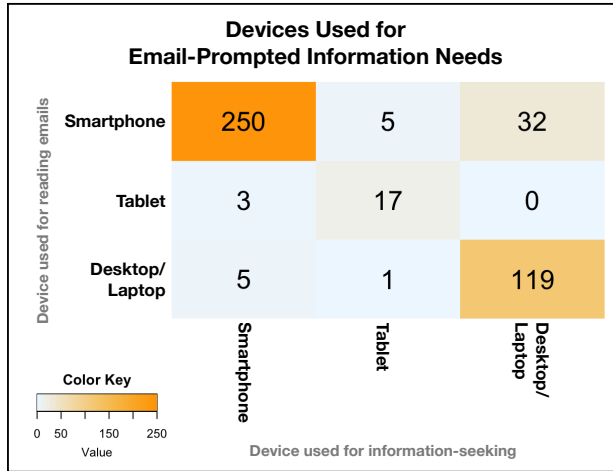
Fig. 10. Participants' device use for their email-prompted information needs. 89% of the email-prompted information needs happened and were addressed on the same device. Values add up to more than the N. of valid diaries because a diary may specify multiple devices.

applications by themselves to find the information that they needed. In these cases, it was common that participants switched from one device (e.g., smartphone) to another device (e.g., laptop). For instance, P39 received a notification that his checking account balance was lower than a certain amount. He read this email on his phone but switched to his laptop to visit the bank's website. He stated that the desktop version of the online bank was easier to use than the version on the phone.

4.4.3 Devices Used for Email-Prompted Information Needs. Fig. 10 shows the devices that participants used both in reading the email and in addressing their email-prompted information needs. Participants were most likely to used the same devices for checking email and looking for needed information (N=386 diary entries, 89% of the valid diaries). Most of the email-prompted information needs happened and were addressed on smartphones (N=250, 58%), followed by using the desktop/laptop for both email-checking and information-seeking (N=119, 28%).

Interestingly, there were a number of email-prompted information needs where the message was read on the phone, but the need was addressed on the computer. 32 (7%) of the diary entries specified that participants switched from email-checking on their *phone* to information-seeking on *computers*. Our interview results suggested that this might because the corresponding mobile web or app designs are not as user-friendly to find detailed information. As in P39's example (described in 4.4.2), he switched to his computer after he saw his bank's notification because the banking app on his phone was hard to use.

5 ONLINE SURVEY RESULTS

The survey was conducted after the diary study to further quantify the types of information needed for a variety of email categories. We examined five email categories (Notification, Deal/Advertising, Newsletter, Bill, and Event) in this survey and collected 733 valid responses from SurveyMonkey (N=222) and MechanicalTurk (N=511) as described in 3.3. We asked participants to recall specific information needs that they had in each category, and Figure 11 shows the percentage of respondents that could recall email-prompted information needs related to each of the five email types. Respondents were most likely to to recall email-prompted information needs caused by Notification messages (87%, N=640), followed by Deal/Advertising messages (83%, N=605). Event messages, consistent with the diary study results, had the smallest number of participants who could recall
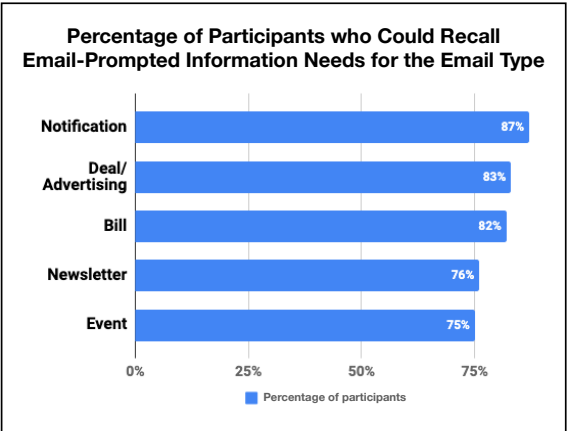
Fig. 11. The percentage of participants that could recall email-prompted information needs related to each of the five mail types. All of the five message types could be recalled by 75% of the participants or more.

related experiences (75%, N=548). However, different from our diary study results, the order of Newsletters and Bills was switched. Survey respondents were more likely to recall email-prompted information needs caused by Bill messages (82%, N=603) compared to Newsletter messages (76%, N=557). A possible reason is the number of these two types of messages that users may receive within a time span. The diary study lasted for two weeks, while the survey was not bounded by a time range. Bill messages occur less frequently within a two week span, but more users have email-prompted information needs with Bill messages over time.

5.1 What Information Content was Needed for Different Message Topics?
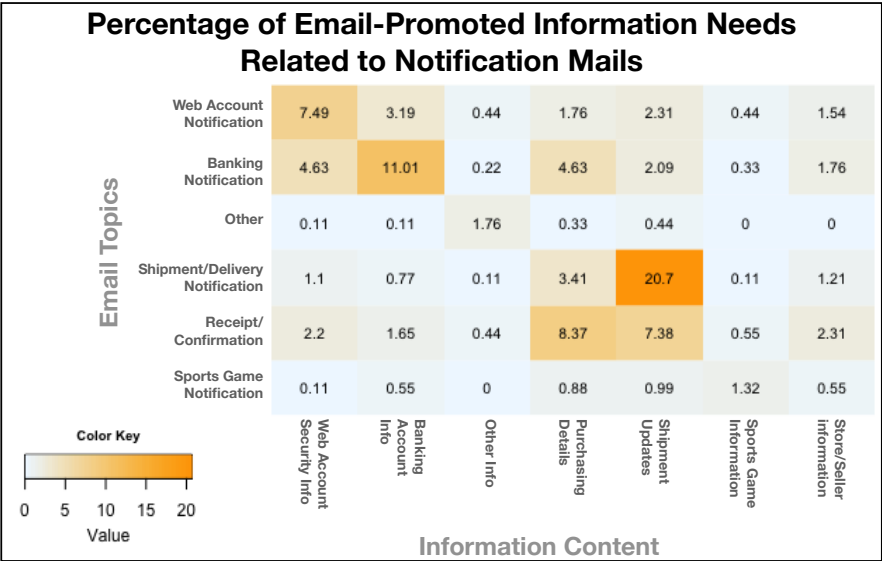

Fig. 12. Email topics and needed information content for Notification messages. This heatmap consists of 908 needs from 87% of participants (N=640).
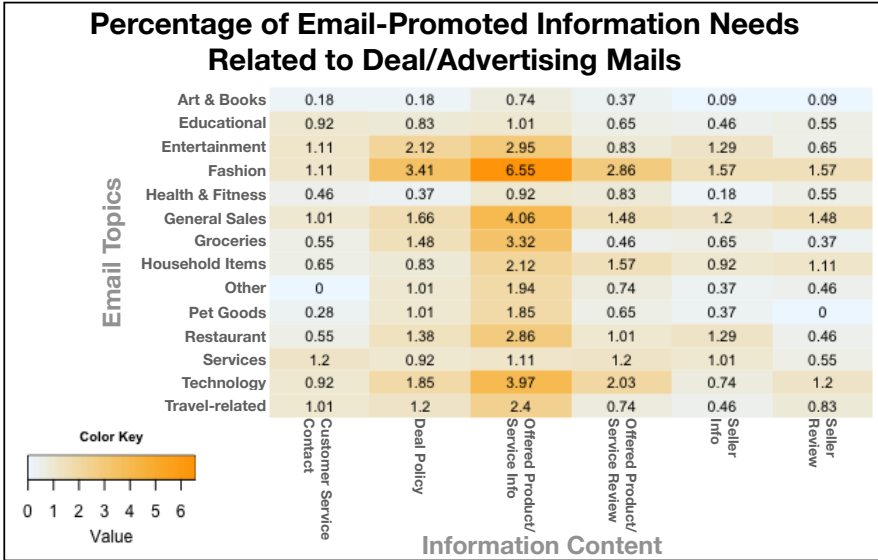
Fig. 13. Email topics and needed information content for Deal/Advertising messages. This heatmap consists of 1084 needs from 83% of participants (N=605).

Fig. 14. Email topics and needed information content for Newsletters. This heatmap consists of 927 needs from 76% of participants (N=557).

Fig. 12 - 16 are heatmaps that present the *percentages* of each email topic/information need among all needs of that email type. For example, 21% of all email-prompted information needs caused by Notification messages were for the information type Shipment Update from emails of the type Shipment/Delivery Notification (Fig. 12). Note that a respondent could specify multiple needs for a message in their survey response. For instance, if a participant looked for (1) Product

Percentage of Email-Promoted Information Needs Related to Bill Mails

Email Topics	Current Bill Details	Other Info	Past Bill(s) Details	Payment Instructions	Related Service Details	Customer Service Contact
Banking	12.7	0.45	5.84	3.15	2.02	2.13
Electricity/Gas	7.75	0.22	3.15	1.91	1.12	1.01
Healthcare	2.58	0.22	1.01	1.46	0.56	1.46
Internet/phone/TV	11.01	0.11	3.93	3.15	1.8	2.7
Online Services (e.g., Netflix)	3.93	0.45	2.58	2.58	1.8	1.8
Other	1.8	0.56	0.45	0.22	0.11	0.22
Physical Services	0.22	0	0.11	0.34	0.56	0.45
Rent/Mortgage	1.57	0	0.56	0.56	0.11	0.34
Other	1.46	0	0.9	0.79	0.79	1.35
Water/Sewer	0.67	0	0.56	0.45	0.11	0.11

Information Content

Color Key: 0 2 4 6 8 12 Value

Fig. 15. Email topics and needed information content for Bill messages. This heatmap consists of 890 needs from 82% of participants (N=603).

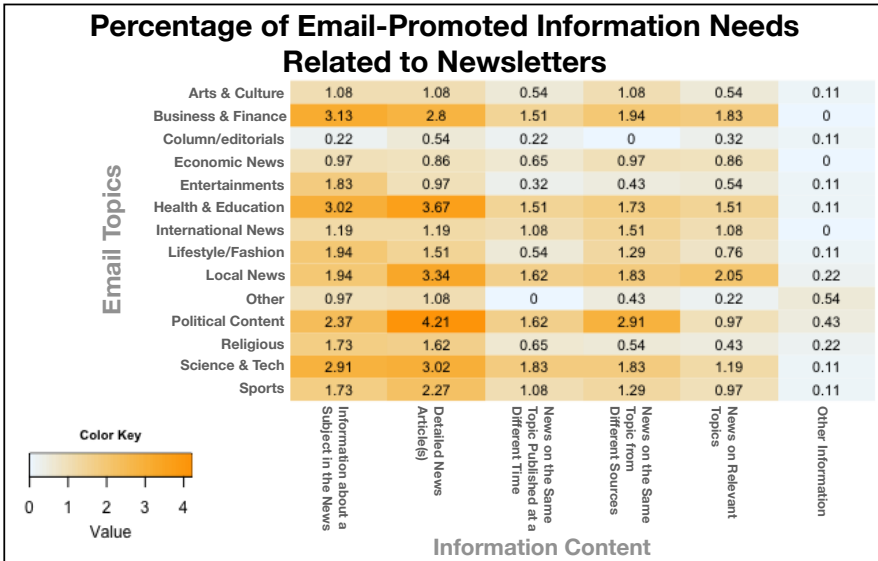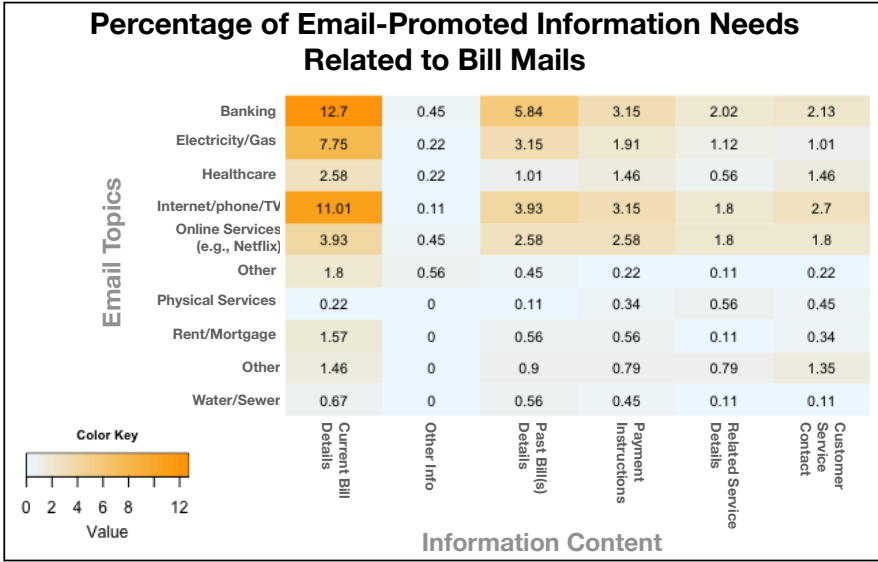**Percentage of Email-Promoted Information Needs Related to Event Mails**

Email Topics	Ongoing Event Status	Event Logistics	Event Policies	Organizer Information	Other Info	Review on Events
Art	1.22	1.67	1.11	1.22	0	1.11
Educational	1	1.44	0.89	1	0.11	0.67
Movie	0.44	1.33	0.56	0.56	0.22	1.33
Music	1.33	3.11	2	0.78	0.33	0.67
Online	2.33	7.33	1.44	1.78	0.67	2.22
Other	0.56	1	0.44	0.22	0.89	0
Political Events	0.44	2.67	0.78	0.44	0.11	1
Private	0.56	2.11	1	1	0.22	0.78
Sporting Events	2.11	2.56	1.11	1.44	0	0.78
Theatrical	0.56	1	0.44	0.44	0.22	0.56
Tour	0.67	1.11	0.56	0.56	0.22	0.44
Work-related	1.78	5.67	1.44	2.44	0.22	0.89

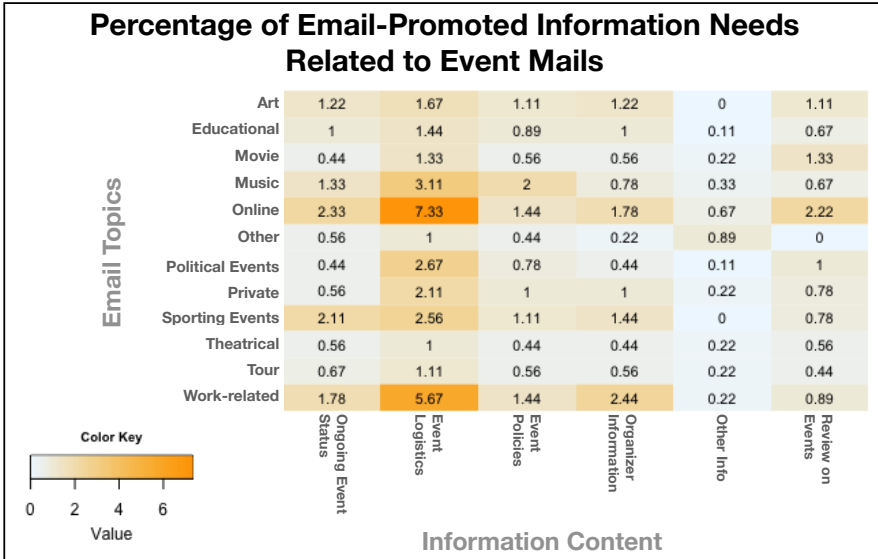*Information Content*

Color Key: 0 2 4 6 Value

Fig. 16. Email topics and needed information content for Event messages. This heatmap consists of 900 needs from 75% of participants (N=548).

Details, (2) Product Review, and (3) Seller Details for a Deal/Advertising message on fashion, their responses were then counted as three email-prompted information needs. We briefly describe the need distribution of the five mail types:

- *Notification.* Fig. 12 presents the results of Notification messages. Among the 908 email-prompted information needs under Notification messages, 21% of the needs were caused by

Package Shipment notifications. With this type of message, participants were most likely to look for information of the package's shipment status.

- *Deal/Advertising.* Fig. 13 presents the results of Deal/Advertising messages. Among the 1084 email-prompted information needs caused by Deal/Advertising messages, 7% of the needs were caused by Deal/Advertising messages on Fashion topics. These messages triggered participants to look for details of the products on sale or being discounted.
- *Newsletter.* Fig. 14 presents the results of Newsletter messages. Among the 927 email-prompted information needs caused by Newsletter messages, 4% of the needs were triggered by Newsletters of which the topic was political content. The most needed information for these newsletters was the detailed version of the articles included in the newsletters.
- *Bill.* Fig. 15 presents the results of Bill messages. Among the 890 email-prompted information needs caused by Bill messages, 13% of the needs were bills from a bank, such as credit card bills or loans. The top information that participants looked for was the detail of the current bill.
- *Event.* Fig. 16 presents the results of Event messages. Among the 900 email-prompted information needs caused by Event messages, 7% of the needs were about general online events, and the needed information content was event logistics.

In the five heatmaps, we can see several themes. First, each heatmap has an uneven distribution of email-prompted information needs. For example, among the needs prompted by Notification mails (Fig. 12), the need to seek Shipment Updates triggered by a Shipment Notification message has the highest percentage (21%), whereas each of the other needs was around 10% or less. The other four heatmaps (Fig. 13 - 16) also share similar patterns. These uneven distributions indicate that each email type is more likely to trigger certain combination email topics and information content.

Second, Deal/Advertising messages trigger more types of information needs per message. Although Deal/Advertising messages ranked second (83%, N=605) in terms of prevalence across participants, it led to the highest number of email-prompted information needs among the five message types (N=1084). On average, a Deal/Advertising mail led to (1084/605) = 1.79 email-prompted information needs, which is the highest among the five email types (Notification: 1.42; Newsletter: 1.66; Bill: 1.48; Event: 1.64). This result shows that a Deal/Advertisement email is more likely to inspire users to look for multiple types of external information.

Finally, information needed for Bill and Event messages is focused regardless of the specific topic of the message. The heatmaps of these two mail types (Fig. 15 and 16) show that the information needed for these two email types is focused on specific content across email topics. For Bill messages, Current Bill Details were needed in 44% of email-prompted information needs; For Event mails, Event Logistics were needed in 31% of email-prompted information needs. This focused pattern of the information needs for Bill and Event messages highlights that the information needed for each of the two mail topics is uniform in spite of diverse email topics. Notification messages display a different focused pattern (Fig. 12). This pattern is related to the broad array of notification emails that a user might receive. Every message topic in Notification messages is likely to trigger needs in different types of information content. For instance, a Shipment Notification mail is more likely to trigger the need of Shipment Updates than the need of Banking Account Info.

These findings point to an opportunity for providing specific types of information on specific types of messages where there is a high likelihood that a user will be in need of a specific piece of data. We will return to this point in the Discussion and Design Inspiration sections where we created mockups of concepts to assist users with related information while viewing an email message.

6 LIMITATIONS

While our methods helped us to understand email information needs from a variety of perspectives with a broad range of participants, there are some limitations to our method and the timing of our research. First, this study was conducted during the COVID-19 pandemic, which was particularly acute in the United States. Most of the country was not traveling during this time and many live events and indoor restaurants were closed. Dining, event, and travel related information needs may be under counted due to these changes. In addition, many were working from home and not commuting, which may have increased the time available to work on email and information needs.

Our study only included participants from the United States. While we interviewed and surveyed a broad range of the population, uncovering differences in email-prompted information needs in other countries was beyond the scope of this work. We encourage others to explore these needs around the world, especially in locations with dramatically different personal email use such as China, Taiwan, and Indonesia. In these cultures, email is not as commonly used as the main identifier used with stores, and even more personal communication has moved on to other messaging applications compared to the Americas and Europe.

Another limitation was in the frequency of diary entries in our study. Our diary study procedure allowed participants to report only one email-prompted information need at a random time each day. However, as observed in our findings, email-prompted information needs were quite common, and a person might be sparked by more than one email to seek additional information in a given day. Thus while we could report the percentage of days with information needs, we could not count the total number of information needs that people have within a two-week period. Future studies can take this into account and leverage different methods to explore the precise frequency of needs, including the number of needs per day that a user has.

7 DISCUSSION

Our work explored the fundamental nature of information needs that are inspired by messages in personal email accounts. We conducted a diary study and an online survey to contribute knowledge regarding email-prompted information needs. Our 2-week diary study with 49 participants showed that email-prompted information needs happen as often as every other day among more than 80% of our diverse sample of American participants. The diary study also indicated how often each of the email types could lead to email-prompted information needs, in which we found that Notifications, Deals, and Newsletters were the most frequent. In an online survey with more than 700 respondents, we further studied subtopics of five email types and the types of information content that fulfilled corresponding information needs, such as looking for product details for Deal emails covering Fashion topics. In the rest of this section, we discuss how our work contributes knowledge to HCI literature on email and information-seeking, and provide design implications for email applications.

7.1 Uniqueness of Email-Prompted Information Needs

General information-seeking can happen in our daily lives at any moment [13]. Email-prompted information needs, however, are unique in three aspects: emails are the stimulus, the needed information is often of a personal nature, and users are task-switching between email reading and searching for information. We discuss these three aspects below. We also observed differences in the types of information that was sought. While in Church et al.'s study the top categories were Finding and Availability [13], these were relatively low in our dataset focused specifically on information needs sparked by personal email, where Offerings and Persons were the most common categories of information needs.

7.1.1 Emails as a Stimulus. Different from general information needs that could rise at any moment with a wide variety of stimuli, email-prompted information needs are unique because emails work as the stimulus for the information that is needed. Thus the information is largely dependent on the content and properties of the email message, such as its content, sender, or message body.

The temporal patterns of email-prompted information needs is another aspect that reveals emails' unique role inspiring information needs. We identified two temporal patterns of email-prompted information needs, namely 1) the peak time that users address email-prompted information needs matched the peak time of email-checking in a day, and 2) email-prompted information needs were less likely to occur on Saturdays. Our findings mirrored the temporal patterns of email notifications on mobile phones found in prior research [30]. On top of that, our work further extended this literature by finding that email-prompted information needs happened less on Saturdays, but not Sundays. Given that personal email accounts have converted from interpersonal communication channels to B2C communication channels [4], this pattern of email-prompted information needs could be because businesses see lower open rates on the weekend and are less likely to send commercial messages on Saturdays, as shown by data from MailChimp, a large commercial email sending platform [24].

Some systems in the CSCW literature have explored ways for users to find information related to their communication, such as Bentley et al.'s Search Messenger [7]. In this system users could find related restaurant information, videos, and web results while in a person-to-person chat. Our research and the concepts proposed below extend this idea into stimuli created from the mostly business-created emails that people receive in their personal email accounts.

7.1.2 The Personal Nature of Needed Information. The second unique attribute of email-prompted information needs is the personal nature of the needed information. The information needs inspired by emails in personal accounts is often personal and even private. This was specifically salient in needs inspired by Notification messages, where the top needed information was private or restricted data, such as personal finance status, order delivery progress, and event tickets/bar codes. The highly personal characteristic of the needed information distinguishes email-prompted information needs from general information needs that can frequently be fulfilled by general online search. Therefore, access to information inspired by emails often requires access to credentialed systems.

Because of this, users might need to spend more effort accessing and finding information. As we found in our diary, participants might need to postpone their information needs because they are unable to log in to a specific site or app. Difficult to use mobile design of an information source, such as the bank app mentioned earlier, also increased a users' problems in finding the needed information and sometimes required them to switch devices. Even checking the status of a package might involve signing into another account, e.g. Amazon, in order to load the delivery status page. This finding echoes past research that found the importance of source quality over access difficulty if the needed information is important [1], given that personal information tended to be important/urgent. There is a large opportunity to find ways to reduce these barriers to accessing simple but personal information that is related to an email message.

7.1.3 Task-switching between Email and Information. Per our definition, email-prompted information needs are inspired by emails. Thus these needs are likely to happen to a user in the process of checking emails and may cause users to switch between task of reading emails and the task of information-seeking. However, information-seeking is not always straightforward, especially in cases where users need to enter related keywords to search. As Carrascal and Church found, email clients are often involved in complicated application-switching for mobile information needs [11]. Users need to spend more effort locating the information and digging deeper by themselves, which causes them to switch between the task of email-checking to information-seeking. As our users

reported, it was often that they needed to handle other tasks during/after checking email, so they needed to postpone their email-prompted information needs.

Designs that support email-prompted information needs should take into account both information's security and efficiency to access. Bringing key information from disparate systems to the user more directly while on the message screen of their email can help to reduce the barriers to finding the needed information and help users to consume the information that they need while still in the task of reading email. We envision that future email clients can represent needed external information that is corresponding to email types, and thus minimize task-switching and resumption errors as suggested in Wilmer et al. [38]. We will present several design concepts that meet this need in Section 8.

7.2 Design and Research Implications

We see opportunities to present information in email applications to address users' information needs with their personal email account. Given that personal email accounts are less likely to be used for interpersonal communication [4], designers and researchers have the opportunity to reshape email applications to support user needs related to the business-to-consumer content that fills 95% of our personal inboxes [21]. Our work serves as one step to provide deeper understanding and insights about these needs, and contributes design implications for what and how information should be presented to address the email-prompted information needs that we have identified.

Our results contribute a roadmap for what information content should be prioritized to display when users receive certain types of emails with certain topics. For example, seeing the due date and total amount of a bill when reading a Bill message, or seeing related news or the latest polls for a political message are opportunities that exist to augment email messages with related information that users might need at the time of reading the message. We encourage designers to study the heatmaps in this paper to focus on the needs that are most frequent and can cover the largest possible user base.

Secondly, our research suggests that the effort needed to find the information influenced the timing and strategies of a mail user's information-seeking. We argue that displaying the needed information with the corresponding email messages upfront in the user interface can improve the user experience by reducing user effort on information-seeking. Since different email types may trigger users to look for different information, future research can further investigate the most appropriate format to display information for each type of email-prompted information need, and the types of privacy that should be implemented for each type. These types of strategies could allow for more email-prompted information needs to be met in situ when the email is first opened, instead of being postponed for a later time due to the complexity of the information seeking task.

Our results also revealed that users' email-prompted information needs vary because of contextual factors such as time, current task, or the needs of other stakeholders. Broadly speaking, information needs are context-dependent [13, 32]. The same stimulus might trigger a person to look for different information or postpone their information seeking when the context changes (such as when arriving at an airport or physical store). Future research on email-prompted information needs can more deeply investigate the contextual factors other than time and stakeholder that influence email-prompted information needs.

8 DESIGN INSPIRATION AND EVALUATION

Based on the results of our diary study and survey, we created five static design mock-ups that address five of the top email-prompted information needs. The five mock-ups are shown in Fig. 17: (A) Sport game highlights for an Sport Event mail, (B) Current bill details for a Bill mail, (C) Latest political polls for Political Content Newsletter, (D) Related news article for Non-Political Newsletter,

	Group	N
Gender	Man	127
	Woman	149
Age	18-29	79
	30-44	67
	45-60	87
	61 and above	43
Annual Income	$0-$49,999	116
	$50,000-$99,999	78
	$100,000-$149,999	38
	$150,000-$199,999	13
	$200,000 and above	13
	Not available (prefer not to answer or blank)	18

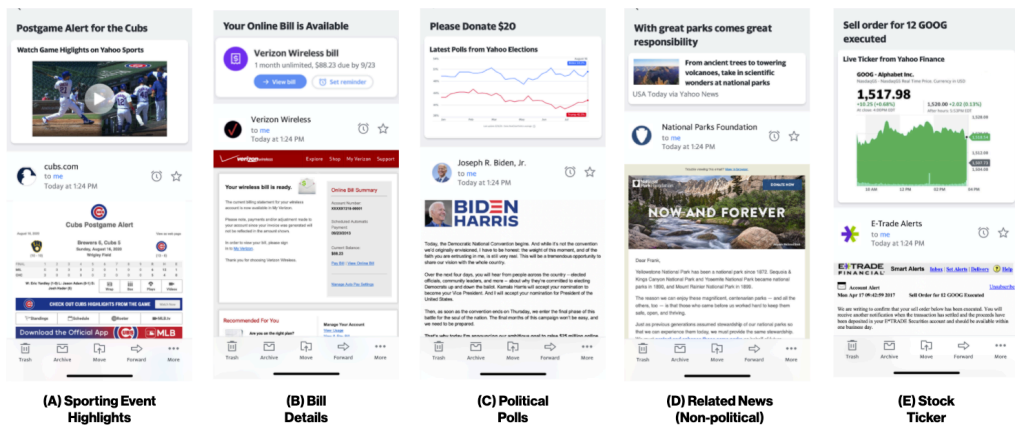Table 5. Demographic information of proof-of-concept evaluation participants (N=276).

Fig. 17. The five static mock-ups we tested in the evaluation. The designs are: (A) Sport game highlights for a Sport Event mail, (B) Current bill details for a Bill mail, (C) Latest political polls for a Political Content Newsletter, (D) Related news article for a non-political Newsletter, and (E) Stock ticker for a Notification on finance messages.

and (E) Stock ticker for Notification on Personal Finance messages. Note that we did not design mock-ups for shipment progress for Notification messages since existing email applications such as GMail and Yahoo Mail already support this need with top-of-message real time package tracking. We also did not create a design for the Deal/Advertisement use case, as existing email clients such as Yahoo Mail already extract specific deals or show information about specific products above the message. Thus the five designs that we tested were for potentially novel features of personal email clients that were not already available at the time of the study.

We conducted a preliminary concept evaluation survey to see if people could determine if these concepts were useful for their own lives and the types of personal email content that they receive. The survey was targeted to a US representative sample of 276 participants (based on age, gender, income, and region) on the SurveyMonkey Audience platform (Table 5). We displayed concepts in a random order and asked participants with the following prompt, "*Do you subscribe to (one of the email types shown in the mockups) emails?*" and if so, "*How much interest do you have in using an*

	(A) Sports	(B) Bill	(C) Political Content	(D) News	(E) Finance
Percentage of respondents who subscribed to this category of email	33%	72%	43%	52%	36%
Mean of interest	3.83	3.87	3.06	3.75	3.70
(a) Median of interest	4	4	3	4	4

	(A) Sports	(B) Bill	(C) Political Content	(D) News	(E) Finance
Percentage of respondents **(b)** that prefered the design	15%	45%	8%	14%	12%

Table 6. Table (a): the percentage of respondents who subscribed to the corresponding mail type, and the mean/median of interest in the design among these participants. Table (b): the percentage of respondents that selected the design as their favorite of the ones presented.

email application that provides such external information in the screenshot?" We have used "interest" in past research to identify concepts that users find helpful to their lives. This data combined with frequency (for example by looking at email open data for these types of messages at scale in a personal email client), can often highlight features that will receive high user engagement. At the end of the survey, we asked participants for their favorite of all five designs.

Table 6a displays the mean and median ratings (5 = Extremely interested, 1 = Not at all interested) for interest in the five designs among participants who received the corresponding type of emails. Presenting details of the current bill for Bill messages was the highest rated design. It received a 3.9/5.0 rating from participants who received Bill mails. The number of participants who received Bill mails (N=199, 72%) was also top among the five email types. On the other hand, the design that presented the latest political poll for a political content Newsletter received a rating of 3.1/5.0, which was the lowest among the five designs. It was also the only one that had a median interest of 3, in contrast to the 4's received by the other four designs.

Table 6b presents the percent of participants who rated each design as their favorite design. Note that 19 participants who did not prefer any of the five designs (about 7%) were excluded from Table 6b. The design that displays the information of the current Bill, again, was the top among the five mock-ups. Similarly, the political poll design was preferred by the least number of participants.

The evaluation's results suggest that presenting related information above the message is a promising direction for future research and design. Four out of the five concepts received median scores of 4/5 (Somewhat Interested) which is fairly high for initial concept evaluation studies such as this one. We find the case of the political poll interesting. While political content was the most common information need for Newsletters in Phase 2's results, this design received the least number of votes. This may be due to the intense political polarization in America at the moment and many in the population not trusting the news media or polls, or not liking to see their preferred candidate losing by a wide margin in the popular vote. Future research can continue to determine what and how political information should be presented with associated Newsletters.

While only a very preliminary evaluation, this quick study allowed us to check our design implications via these concepts with potential users of these features to validate that there would be value and interest in following our design guidelines. We note that after this research was conducted, this feature was launched on our email platform in March, 2021 for sports and finance-related emails. Sports emails contained the score and game highlight video for any team mentioned in the

email while finance emails would have the latest stock graph for any tickers/companies mentioned within the email. A feature for bills was also launched, whereby a user would see bill due dates along with any significant changes since the previous bill at the top of their Inbox. We have seen positive levels of user engagement with these widgets. This deployment validated the findings from our preliminary research study described in this section.

9 CONCLUSION

In this paper, we have presented a mixed-methods study exploring a unique type of information need – *email-prompted information needs.* Through a two-week diary study, and an online survey with over 700 participants, we explored a variety of aspects of email-prompted information needs. Our work uncovered the types of emails and information involved in common email-prompted information needs. We also identified contextual factors that play a role in when and how users look for information to fulfill their email-prompted information needs.

Our work contributes implications for design to address email-prompted information needs. Based on these implications, we created five design mockups and conducted an evaluation to understand preferences on five types of email related information. While the evaluation was preliminary, it indicates the potential user need and benefit of displaying this type of information above an email message. As future work, we plan to continue to explore the design space for different types of email-prompted information needs, and identify associated ways to present this information securely in the context of the message reading screen.

Additional future work can explore similar concepts in other types of settings. What are the information needs sparked by corporate email, or by a typical session on a social network such as Facebook or Twitter, and how are these needs addressed? The information world has changed greatly since the last surge of research into mobile information needs in the early 2010s, and we hope that this project can spark further research into the types of information needs that modern systems and contexts can create, as well as in creating compelling interfaces to help users to meet these information needs.

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